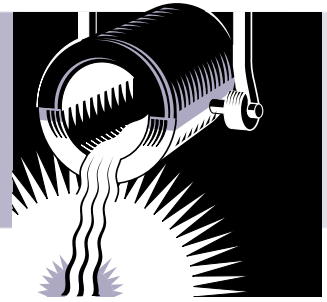


METAL CASTING

Project Fact Sheet



GATING OF ALUMINUM PERMANENT MOLD CASTINGS

BENEFITS

By reducing the amount of metal needed for risers, and by reducing casting defects, improved gating systems will increase casting yield and reduce scrap. This project aims to decrease the scrap rate of aluminum permanent mold castings from the current average of 8% down to 4%, while simultaneously increasing casting yield from 40% to 60%. These improvements will in turn reduce the amount of metal that a foundry needs to melt. This will significantly improve energy efficiency in casting processes since melting is the most energy intensive stage in casting. The results of this project are estimated to save over 7 trillion Btu annually by 2020.

APPLICATIONS

The results of this project can be applied by aluminum permanent mold foundries throughout the metal casting industry.

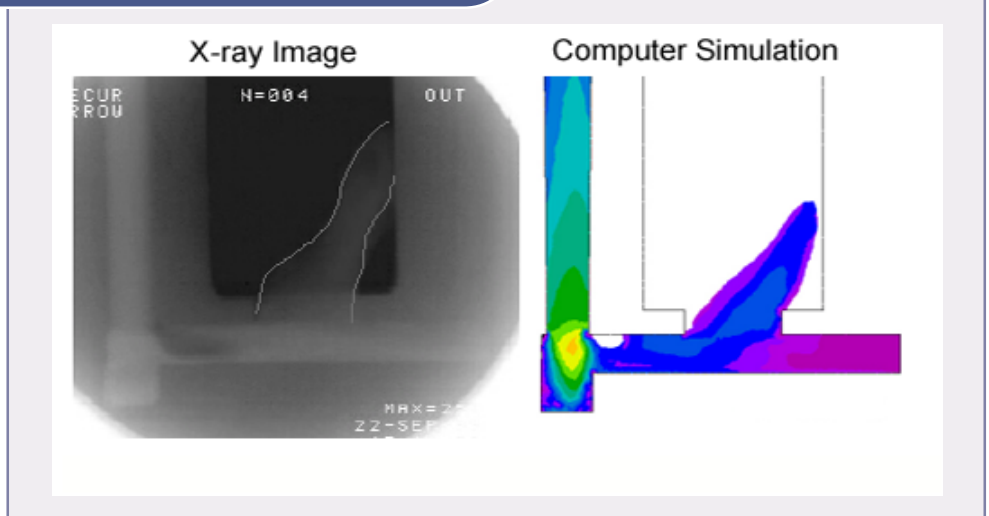
IMPROVED GATING SYSTEM REDUCES DEFECTS AND INCREASES CASTING YIELD

Basic gating design for gravity-fed vertically-parted permanent mold castings has changed little in recent decades. Current designs yield less than optimal results. Improvements in gating designs could significantly reduce casting defects and increase casting yield.

Researchers at Case Western Reserve University in conjunction with the American Foundry Society and industry partners are examining the gating of vertically parted aluminum permanent mold castings through a combination of experiments and computer simulations to develop improved gating designs. Improvements in gating systems aim to eliminate molten metal surface turbulence during mold filling thus reducing casting defects. Minimizing gating and riser size further helps to increase casting yield. In addition, maximizing the thermal gradients during solidification will aid metal feeding.

Through improved gating design, castings can be produced with higher casting yields, lower scrap rates, lower defect contents, and with fewer initial design iterations. Improved designs will be verified with industry experiments (including x-ray radiography) and plant trials on industrial castings.

ENHANCING GATING DESIGN



Jetting of molten aluminum in a bottom gated permanent mold.



Project Description

Goal: The goal of this research project is to provide a basis for improved gating design for vertically-parted aluminum permanent mold castings. It will examine these gating systems through a combination of experiments and computer simulations.

This project began in December 1998 and was recently extended an additional two years to be completed in 2002. Research under the extended project will show how the filling of metal molds is affected by a number of variables including: the design of the gating system, the effect of filters on flow behavior, rate of flow within that system, the type and temperature of the molten metal and mold, the surface roughness and heat transfer through different castings employed in the gating system and mold cavity. This project is co-funded by the Metal Casting Industry of the Future Program and the Aluminum Industry of the Future Program.

Progress and Milestones

Real-time x-ray radiography is being used to visualize the filling of molten aluminum into a set of vertically-parted permanent molds. Experiments are being performed with the same gating designs in specially instrumented permanent molds to measure the thermal history of the casting during mold filling and solidification. The combination of radiography and thermal measurements is being used as benchmarks to verify a computer model of the permanent mold casting process. The verified model is being used to examine a large number of gating and process variations to develop an improved set of gating recommendations and designs. The improved designs will be verified with experiments and plant trials on industrial castings. Excellent progress has been made in the first phase of the project, including:

- Experiments have been performed at participating plants.
- Using a test mold that incorporated a 10 pores per inch (ppi) silicon carbide filter, the flow pattern was recorded with x-ray real-time radiography. This may be the first time that the flow of molten aluminum through a filter has been observed and recorded. The filling of the mold was smooth and without turbulence.
- Using a test mold that incorporated a 20 ppi silicon carbide filter the flow pattern was tested. Results were similar to the 10 ppi filter.
- Finite element modeling is being performed.

Planned activities over 2000 to 2003 will investigate additional aspects of permanent molding, including:

- Effect of Gate Design – Experiments will be run with real time radiography to determine the flow behavior and filling of permanent molds for a number of aluminum castings utilizing different gating systems.
- Effect of Filters and Filter Design on Flow Behavior and Flow Rates – The fill patterns in the presence and absence of a filter, will be investigated and the advisability criteria for incorporation of filter for flow control will also be determined.
- Effect of Molten Metal Composition on Flow Pattern – The aspect of filling will be addressed by comparing the filling pattern of A356 alloy to A380 (a less common in permanent mold casting that is widely used in die casting).
- Effect of Surface Roughness on Flow – Direct evidence on the effect of controlled surface roughness will be acquired.
- Effect of Coatings and Heat Transfer on Flow Pattern – Selected insulating coatings will be applied to the identical molds and flow patterns will be observed.
- Computer Simulation of Flow and Heat Transfer in Permanent Molds – Computer models will be developed to predict the behavior of different gating systems and show how these can be optimized.



PROJECT PARTNERS

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American Foundry Society
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Amcast Automotive, Southfield, MI

Arrow Aluminum Castings, Avon Lake, OH

Bohn Aluminum, Butler, IN

CMI-Michigan Casting Center, Cadillac, MI

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